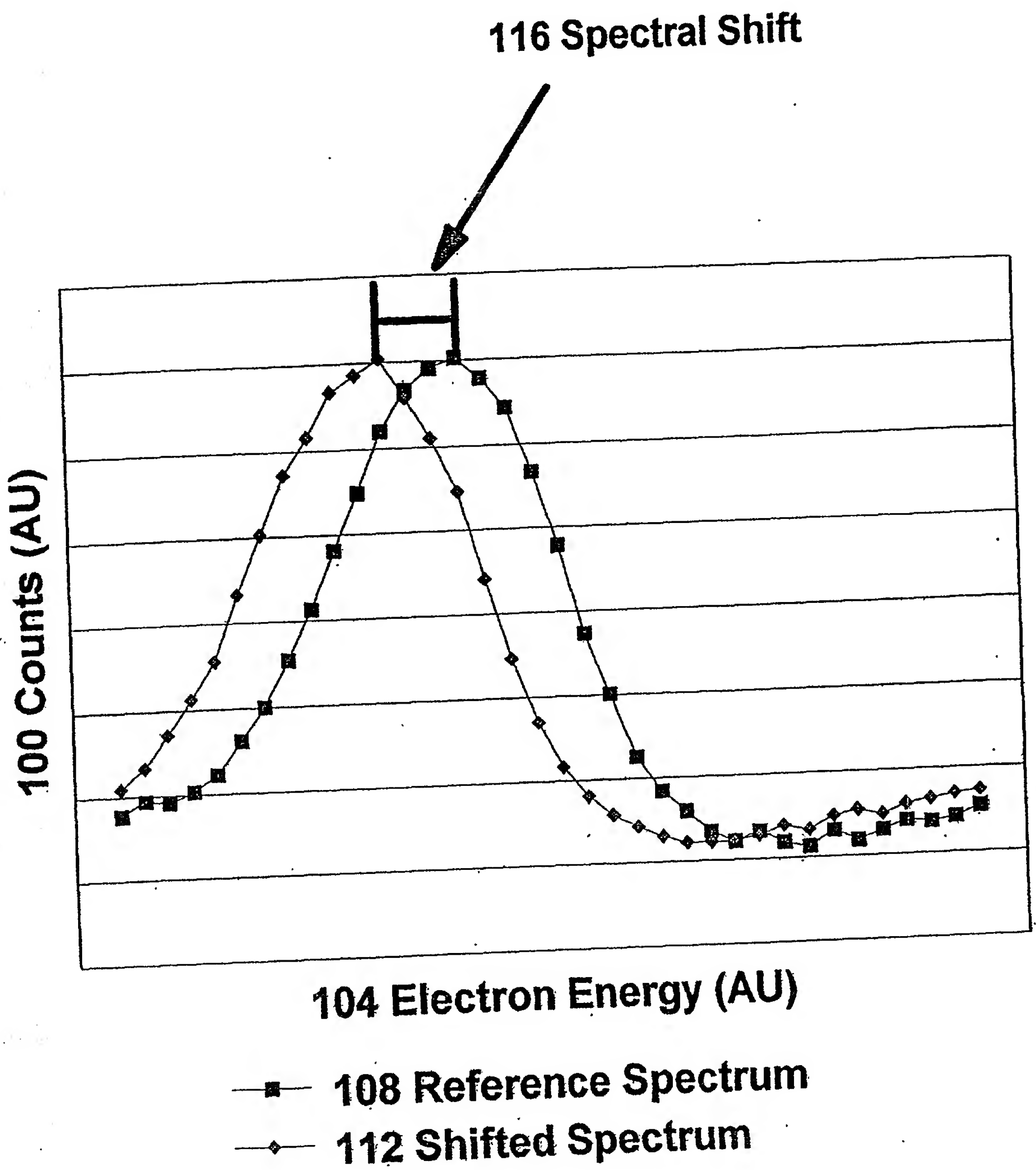

(PRIOR ART)

Fig. 1

Spectra for Depth Profile of Charging SiO_2 on Si
(Si KLL Auger Spectra)
(PRIOR ART)

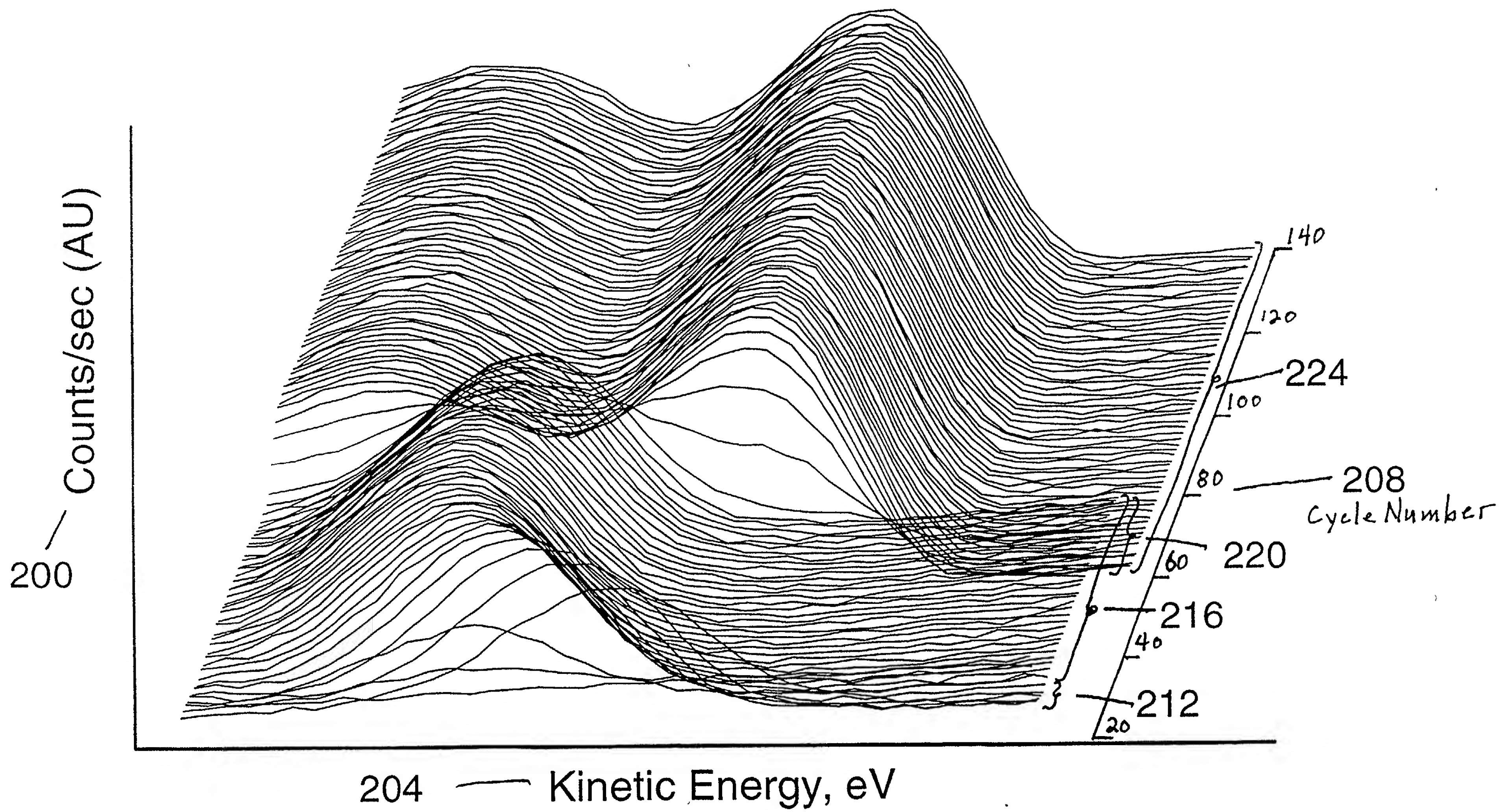

Fig. 2

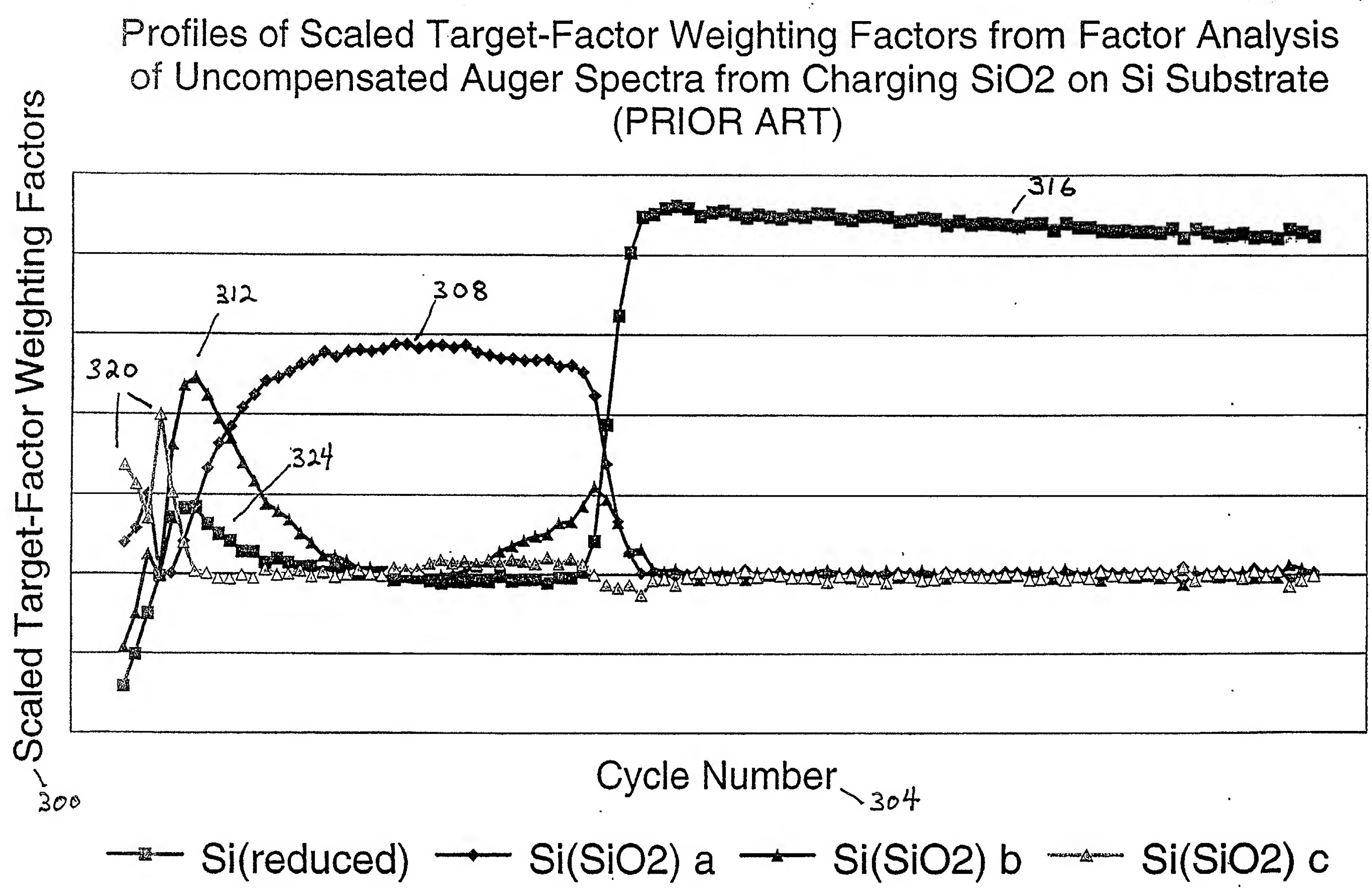
Profiles of Scaled Target-Factor Weighting Factors from Factor Analysis of Uncompensated Auger Spectra from Charging SiO2 on Si Substrate (PRIOR ART)
Scaled Target-Factor Weighting Factors
300
Cycle Number
304
316
308
312
320
324
Si(reduced)
Si(SiO2) a
Si(SiO2) b
Si(SiO2) c

Fig. 3

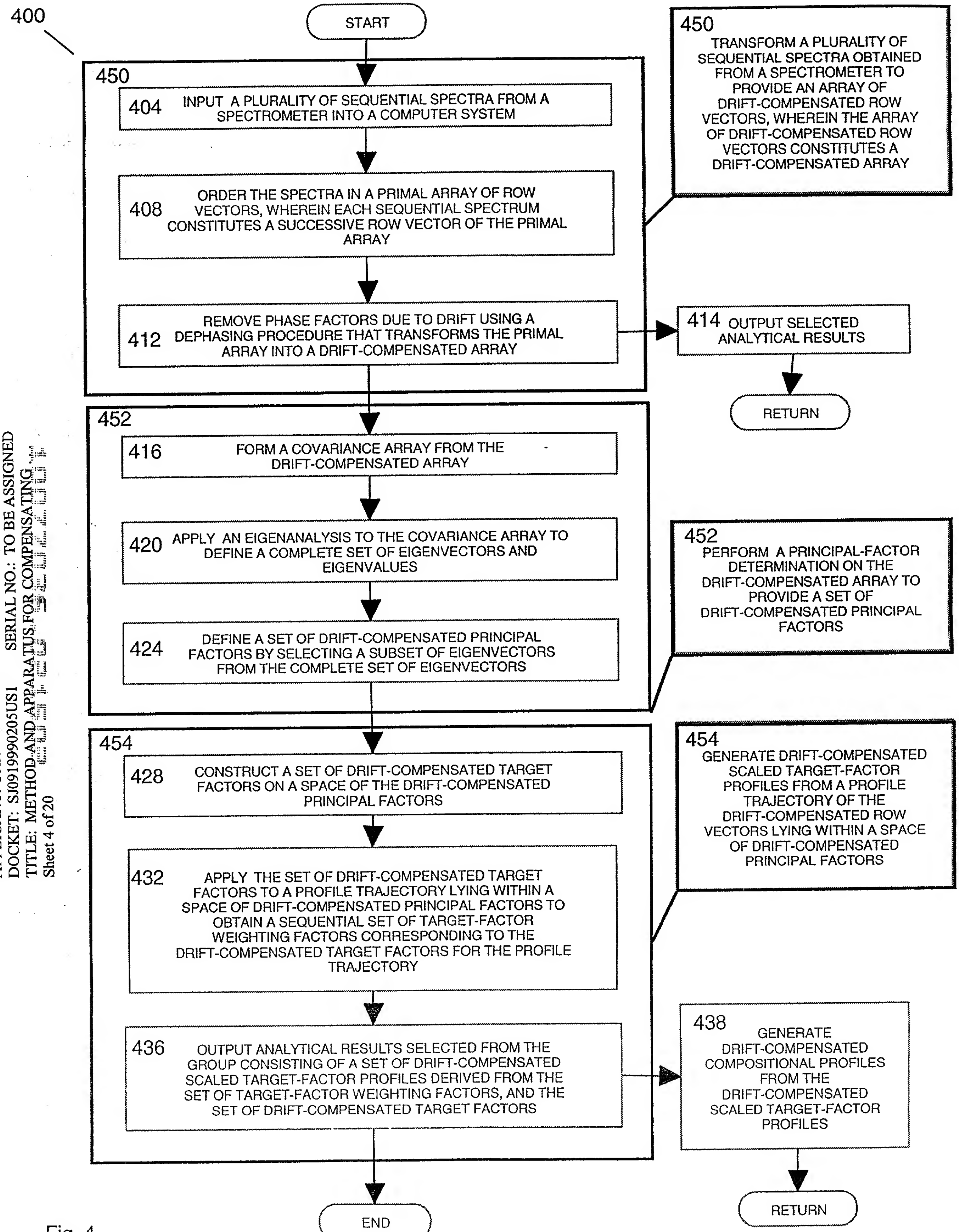
400
START
450
404 INPUT A PLURALITY OF SEQUENTIAL SPECTRA FROM A SPECTROMETER INTO A COMPUTER SYSTEM
408 ORDER THE SPECTRA IN A PRIMAL ARRAY OF ROW VECTORS, WHEREIN EACH SEQUENTIAL SPECTRUM CONSTITUTES A SUCCESSIVE ROW VECTOR OF THE PRIMAL ARRAY
412 REMOVE PHASE FACTORS DUE TO DRIFT USING A DEPHASING PROCEDURE THAT TRANSFORMS THE PRIMAL ARRAY INTO A DRIFT-COMPENSATED ARRAY
450 TRANSFORM A PLURALITY OF SEQUENTIAL SPECTRA OBTAINED FROM A SPECTROMETER TO PROVIDE AN ARRAY OF DRIFT-COMPENSATED ROW VECTORS, WHEREIN THE ARRAY OF DRIFT-COMPENSATED ROW VECTORS CONSTITUTES A DRIFT-COMPENSATED ARRAY
414 OUTPUT SELECTED ANALYTICAL RESULTS
RETURN
452
416 FORM A COVARIANCE ARRAY FROM THE DRIFT-COMPENSATED ARRAY
420 APPLY AN EIGENANALYSIS TO THE COVARIANCE ARRAY TO DEFINE A COMPLETE SET OF EIGENVECTORS AND EIGENVALUES
424 DEFINE A SET OF DRIFT-COMPENSATED PRINCIPAL FACTORS BY SELECTING A SUBSET OF EIGENVECTORS FROM THE COMPLETE SET OF EIGENVECTORS
452 PERFORM A PRINCIPAL-FACTOR DETERMINATION ON THE DRIFT-COMPENSATED ARRAY TO PROVIDE A SET OF DRIFT-COMPENSATED PRINCIPAL FACTORS
454
428 CONSTRUCT A SET OF DRIFT-COMPENSATED TARGET FACTORS ON A SPACE OF THE DRIFT-COMPENSATED PRINCIPAL FACTORS
432 APPLY THE SET OF DRIFT-COMPENSATED TARGET FACTORS TO A PROFILE TRAJECTORY LYING WITHIN A SPACE OF DRIFT-COMPENSATED PRINCIPAL FACTORS TO OBTAIN A SEQUENTIAL SET OF TARGET-FACTOR WEIGHTING FACTORS CORRESPONDING TO THE DRIFT-COMPENSATED TARGET FACTORS FOR THE PROFILE TRAJECTORY
436 OUTPUT ANALYTICAL RESULTS SELECTED FROM THE GROUP CONSISTING OF A SET OF DRIFT-COMPENSATED SCALED TARGET-FACTOR PROFILES DERIVED FROM THE SET OF TARGET-FACTOR WEIGHTING FACTORS, AND THE SET OF DRIFT-COMPENSATED TARGET FACTORS
454 GENERATE DRIFT-COMPENSATED SCALED TARGET-FACTOR PROFILES FROM A PROFILE TRAJECTORY OF THE DRIFT-COMPENSATED ROW VECTORS LYING WITHIN A SPACE OF DRIFT-COMPENSATED PRINCIPAL FACTORS
438 GENERATE DRIFT-COMPENSATED COMPOSITIONAL PROFILES FROM THE DRIFT-COMPENSATED SCALED TARGET-FACTOR PROFILES
RETURN
END

Fig. 4

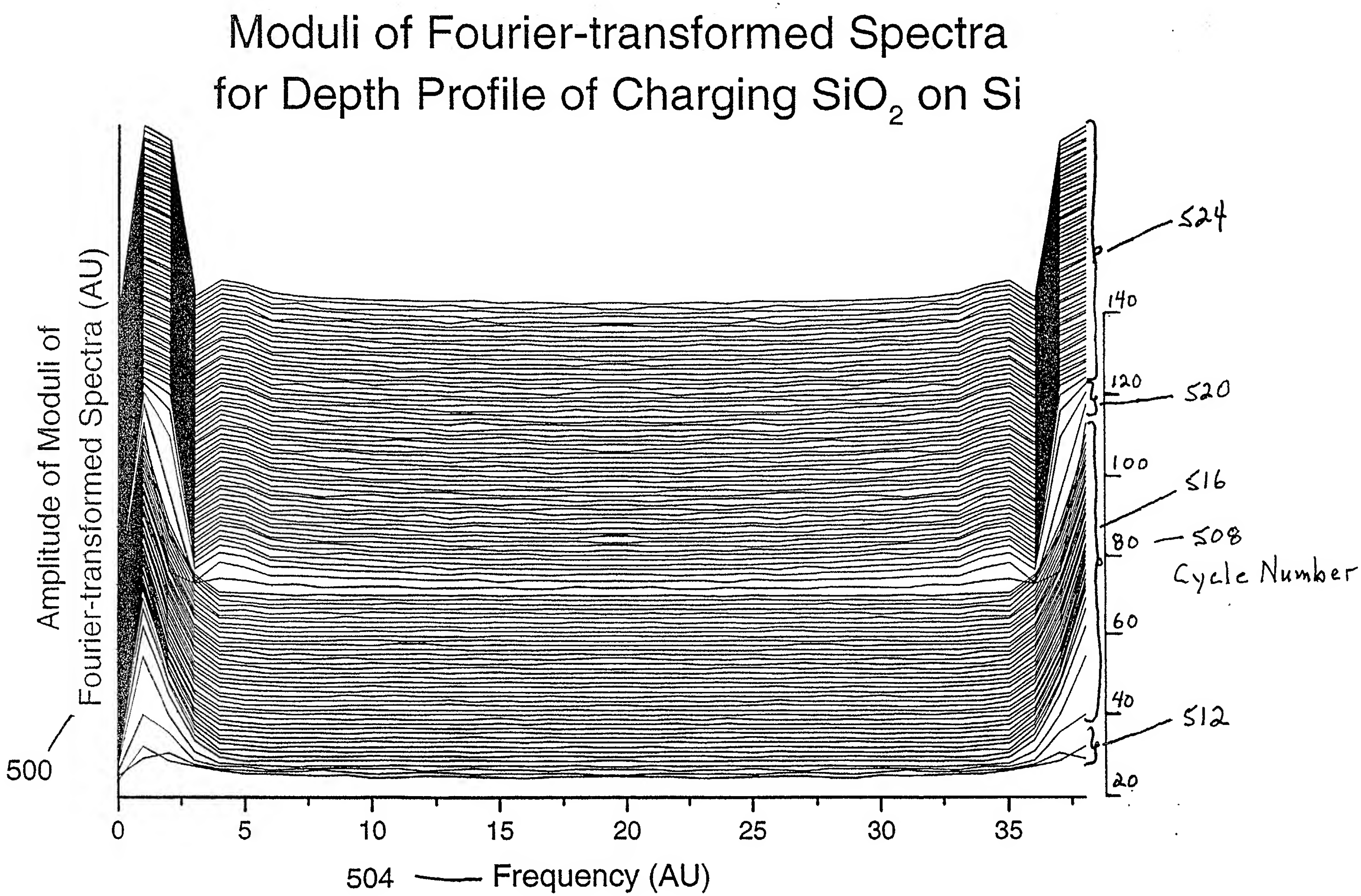
Moduli of Fourier-transformed Spectra
for Depth Profile of Charging SiO_2 on Si
Amplitude of Moduli of
Fourier-transformed Spectra (AU)
500
0
5
10
15
20
25
30
35
504
Frequency (AU)
140
120
100
80
60
40
20
524
520
516
508
Cycle Number
512

Fig. 5

Profiles of Scaled Target-Factor Weighting Factors from Factor Analysis of Moduli of Fast-Fourier-Transformed Auger Spectra from Charging SiO2 on Si Substrate

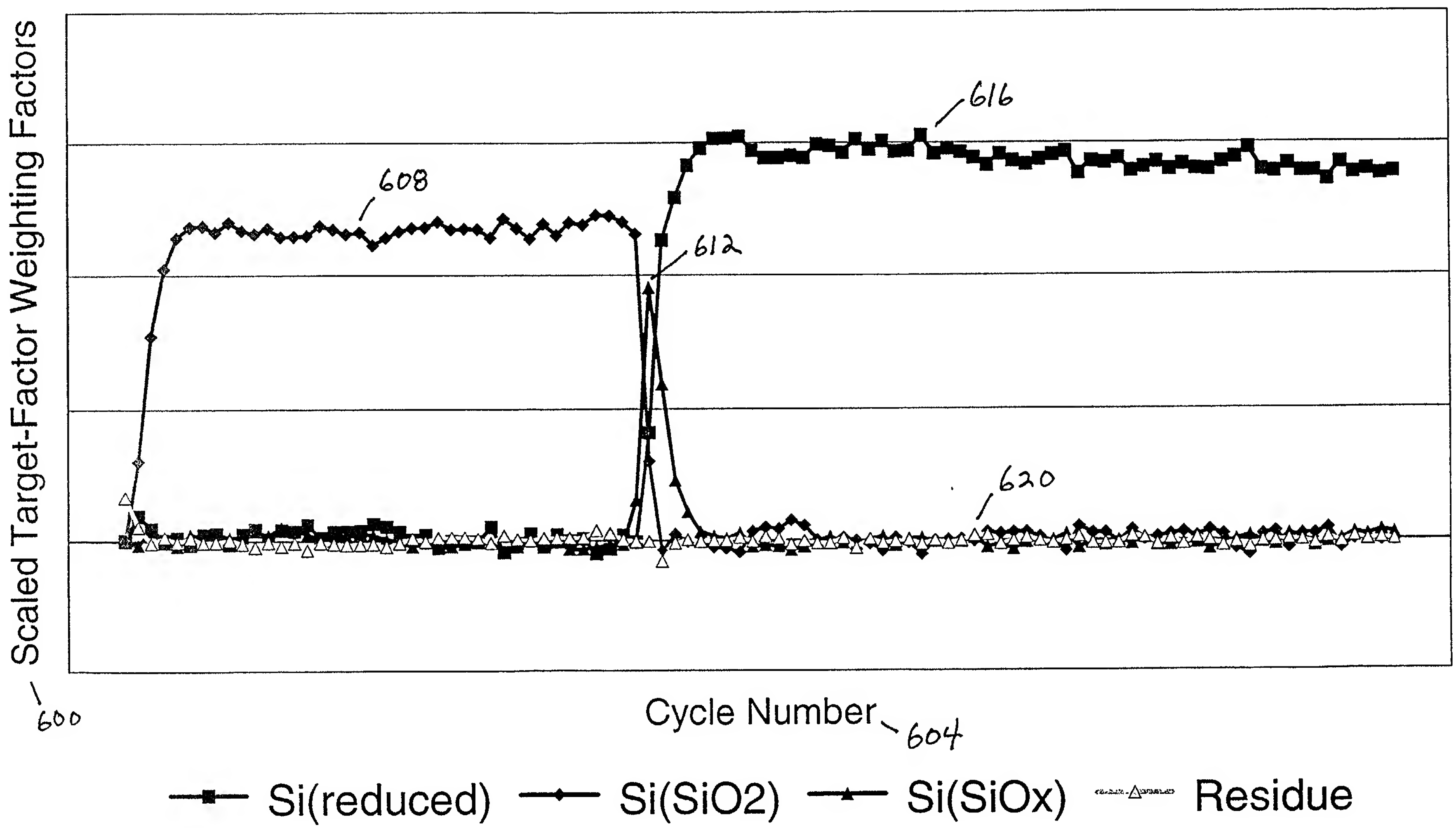

Fig. 6

Drift-Compensated Spectra Synthesized from Selected Reference Spectra Fit to Primal Spectra for Depth Profile of Charging SiO_2 on Si

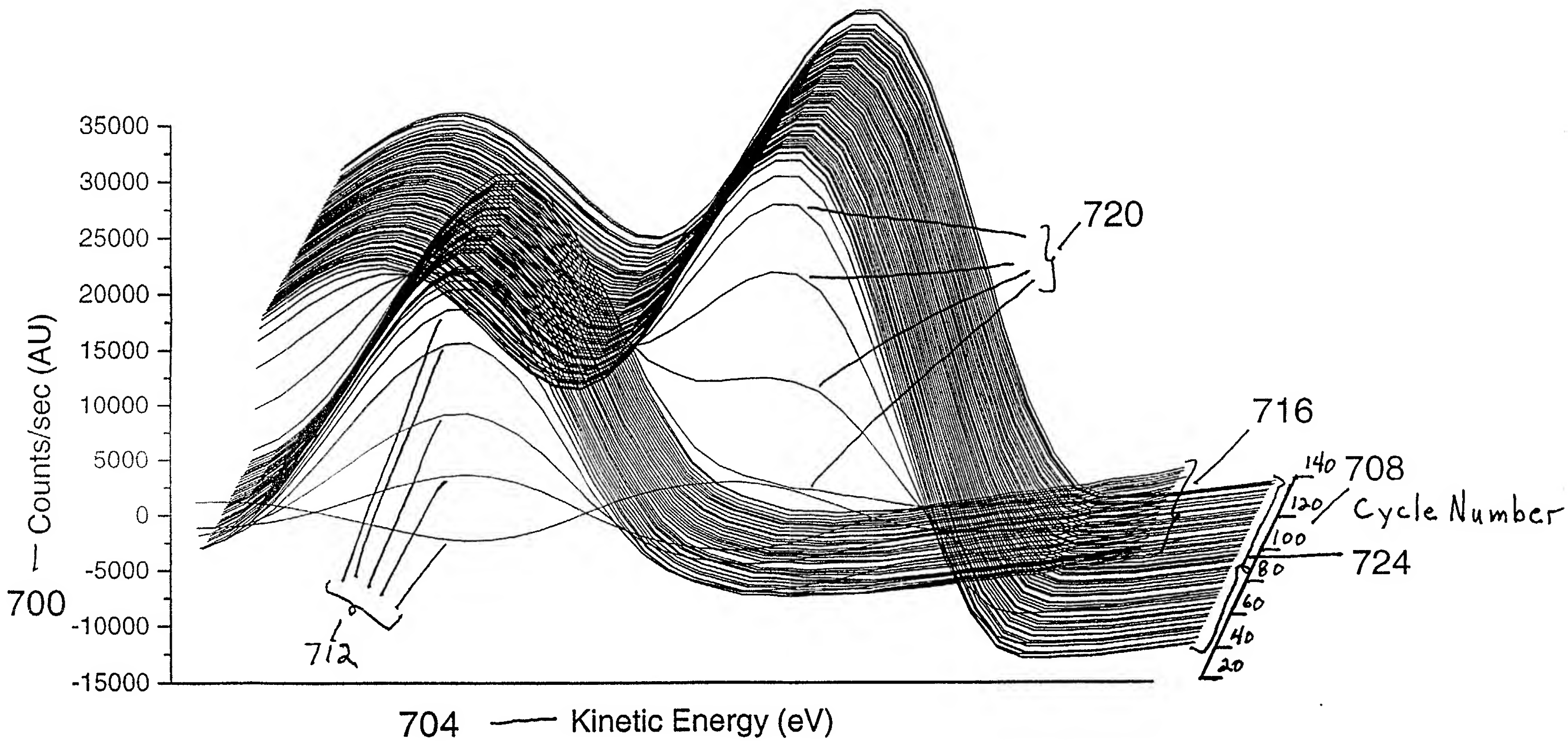

Fig. 7

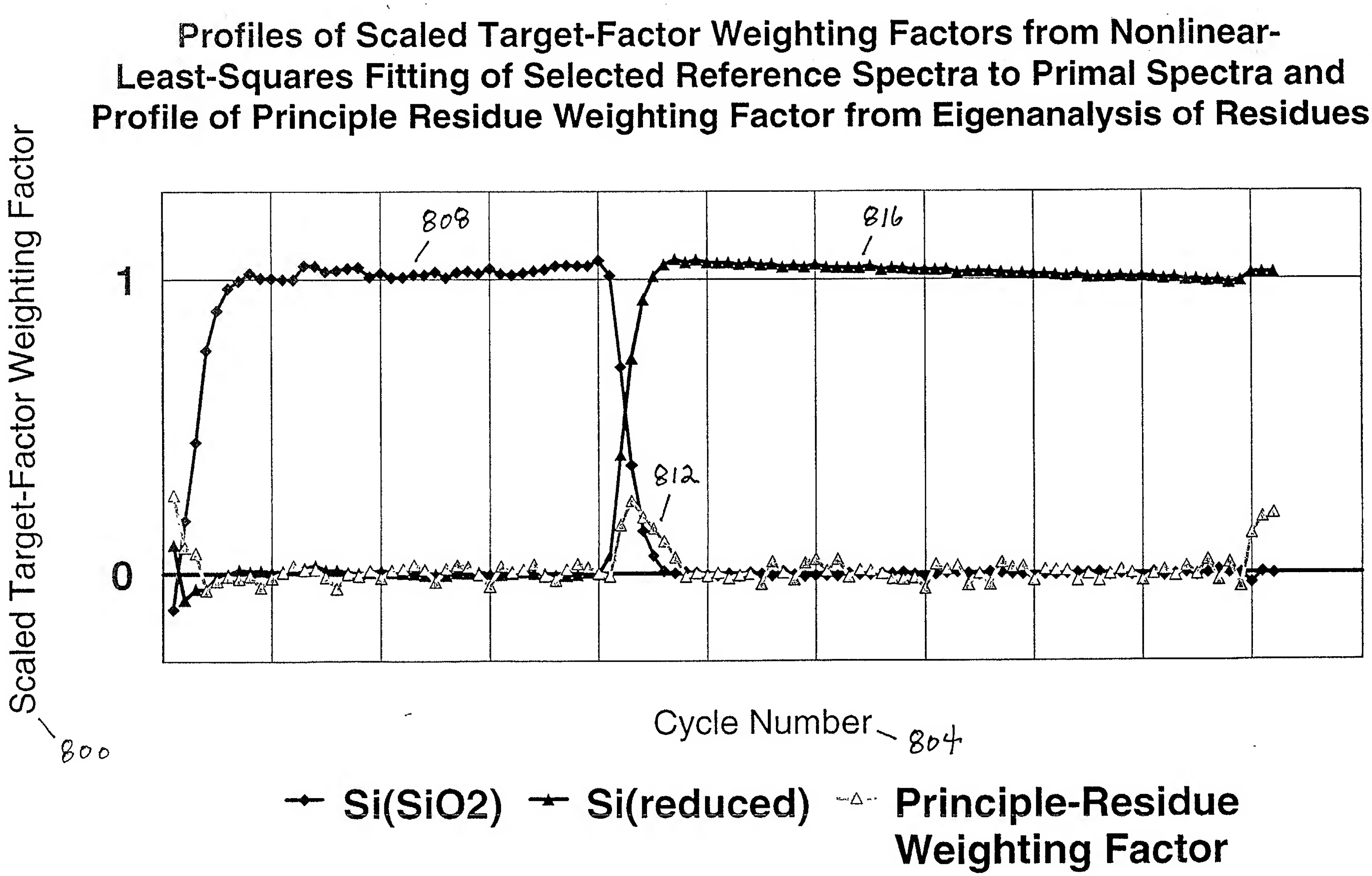
Profiles of Scaled Target-Factor Weighting Factors from Nonlinear-Least-Squares Fitting of Selected Reference Spectra to Primal Spectra and Profile of Principle Residue Weighting Factor from Eigenanalysis of Residues
Scaled Target-Factor Weighting Factor
800
1
0
808
816
812
Cycle Number
804
Si(SiO2)
Si(reduced)
Principle-Residue Weighting Factor

Fig. 8

Profiles of Phase Factors for Selected Reference Spectra Obtained from Fitting to Primal Spectra

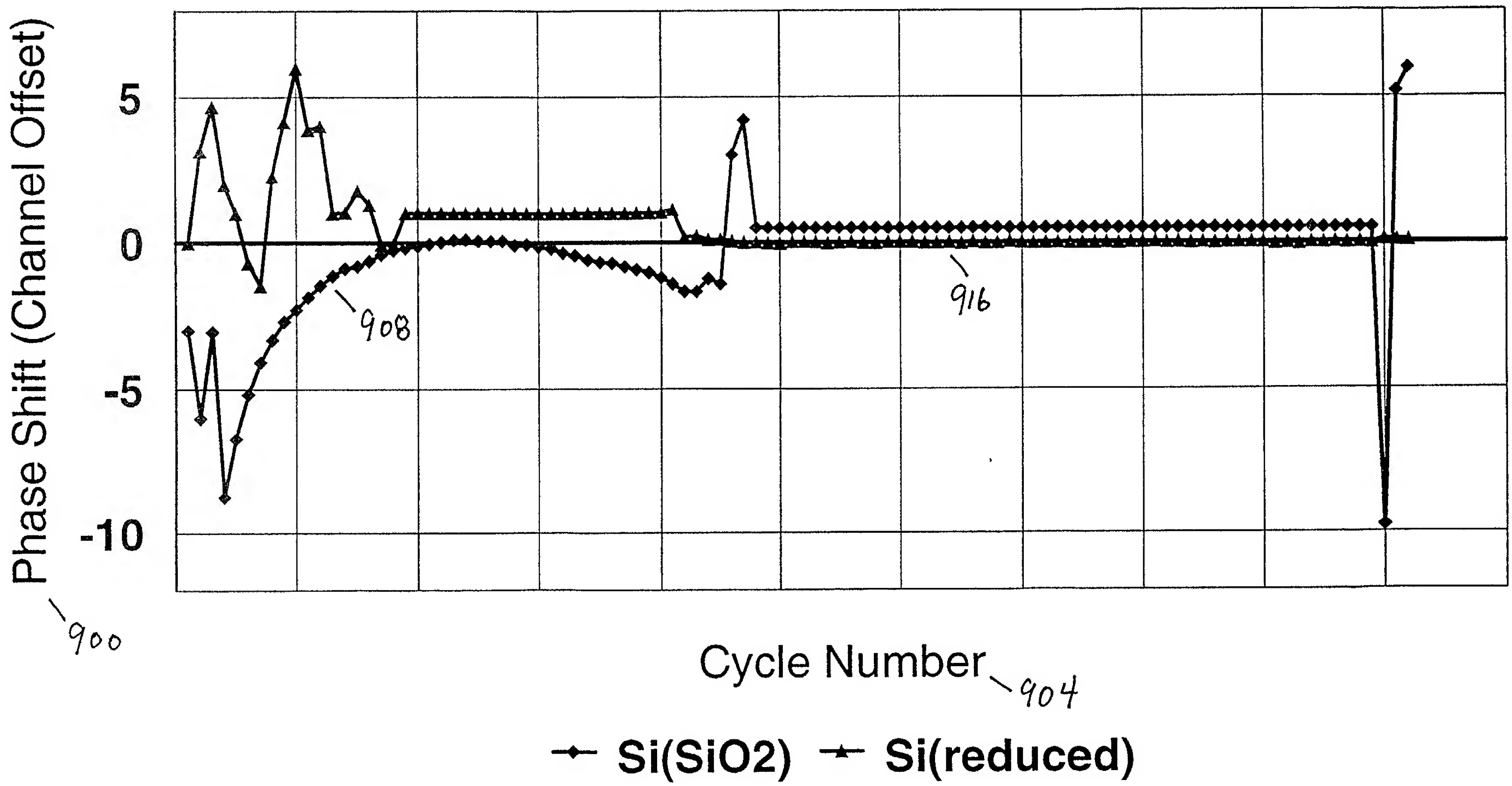

Fig. 9

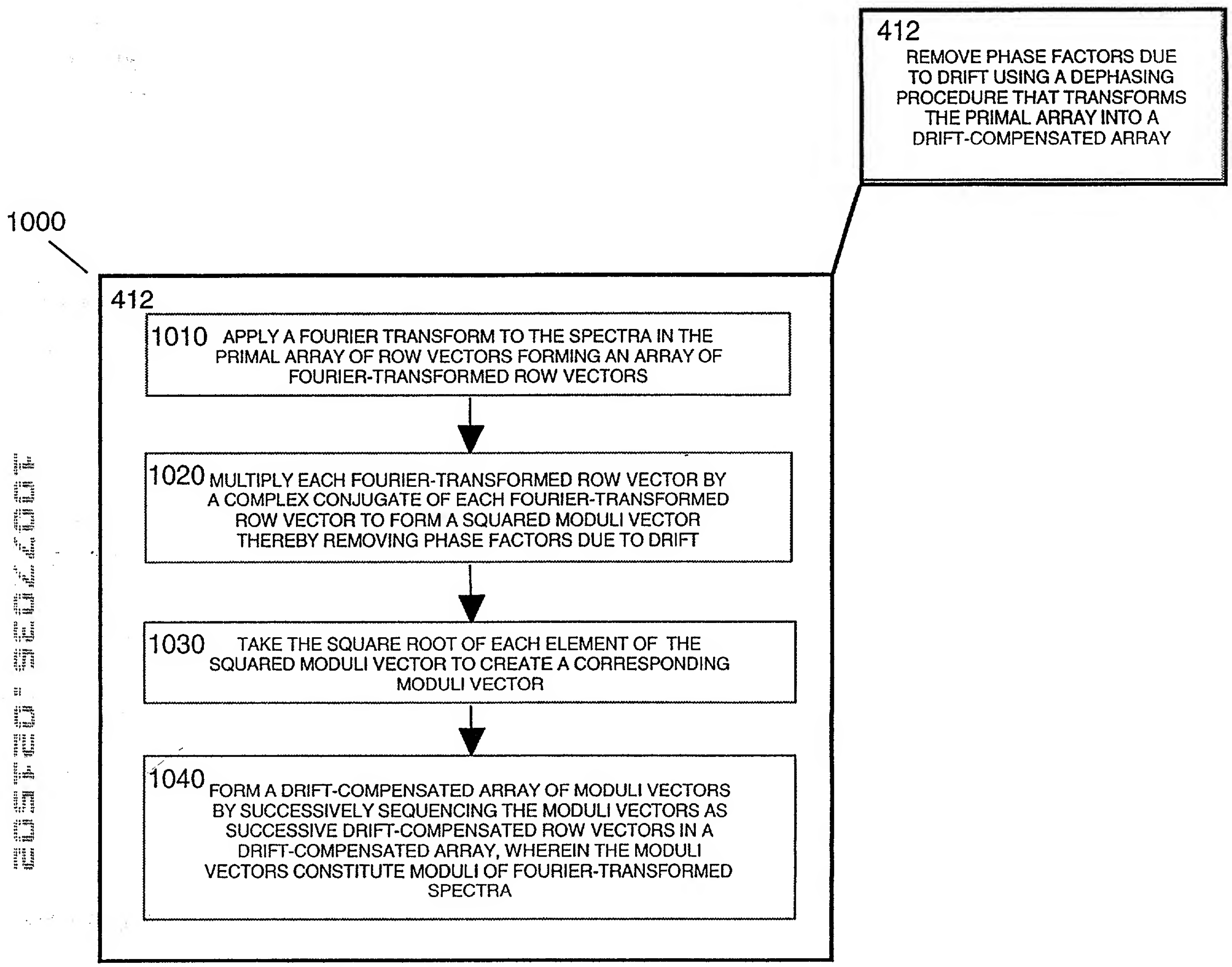
412
REMOVE PHASE FACTORS DUE TO DRIFT USING A DEPHASING PROCEDURE THAT TRANSFORMS THE PRIMAL ARRAY INTO A DRIFT-COMPENSATED ARRAY
1000
412
1010 APPLY A FOURIER TRANSFORM TO THE SPECTRA IN THE PRIMAL ARRAY OF ROW VECTORS FORMING AN ARRAY OF FOURIER-TRANSFORMED ROW VECTORS
1020 MULTIPLY EACH FOURIER-TRANSFORMED ROW VECTOR BY A COMPLEX CONJUGATE OF EACH FOURIER-TRANSFORMED ROW VECTOR TO FORM A SQUARED MODULI VECTOR THEREBY REMOVING PHASE FACTORS DUE TO DRIFT
1030 TAKE THE SQUARE ROOT OF EACH ELEMENT OF THE SQUARED MODULI VECTOR TO CREATE A CORRESPONDING MODULI VECTOR
1040 FORM A DRIFT-COMPENSATED ARRAY OF MODULI VECTORS BY SUCCESSIVELY SEQUENCING THE MODULI VECTORS AS SUCCESSIVE DRIFT-COMPENSATED ROW VECTORS IN A DRIFT-COMPENSATED ARRAY, WHEREIN THE MODULI VECTORS CONSTITUTE MODULI OF FOURIER-TRANSFORMED SPECTRA

Fig. 10

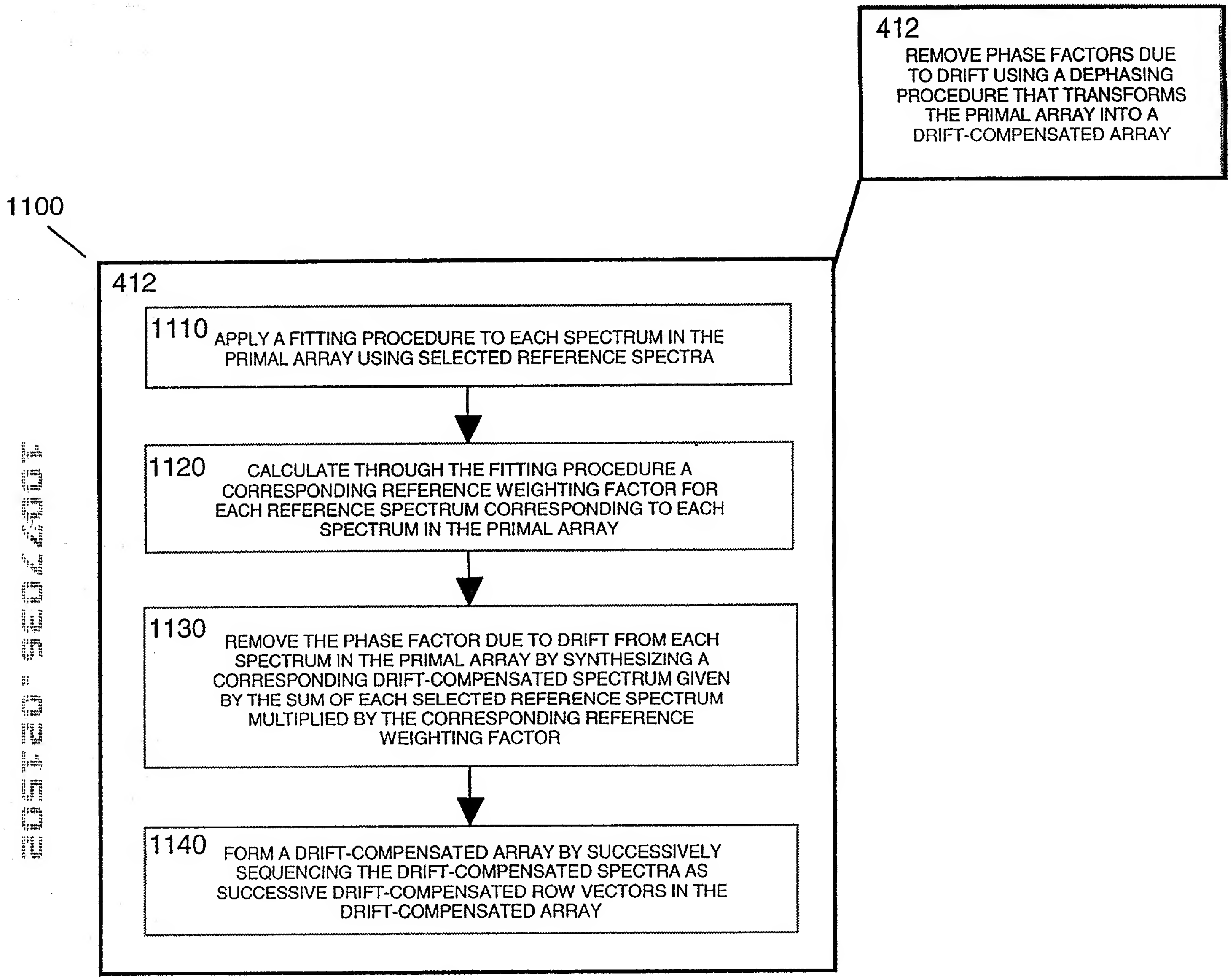
412
REMOVE PHASE FACTORS DUE TO DRIFT USING A DEPHASING PROCEDURE THAT TRANSFORMS THE PRIMAL ARRAY INTO A DRIFT-COMPENSATED ARRAY
1100
412
1110 APPLY A FITTING PROCEDURE TO EACH SPECTRUM IN THE PRIMAL ARRAY USING SELECTED REFERENCE SPECTRA
1120 CALCULATE THROUGH THE FITTING PROCEDURE A CORRESPONDING REFERENCE WEIGHTING FACTOR FOR EACH REFERENCE SPECTRUM CORRESPONDING TO EACH SPECTRUM IN THE PRIMAL ARRAY
1130 REMOVE THE PHASE FACTOR DUE TO DRIFT FROM EACH SPECTRUM IN THE PRIMAL ARRAY BY SYNTHESIZING A CORRESPONDING DRIFT-COMPENSATED SPECTRUM GIVEN BY THE SUM OF EACH SELECTED REFERENCE SPECTRUM MULTIPLIED BY THE CORRESPONDING REFERENCE WEIGHTING FACTOR
1140 FORM A DRIFT-COMPENSATED ARRAY BY SUCCESSIVELY SEQUENCING THE DRIFT-COMPENSATED SPECTRA AS SUCCESSIVE DRIFT-COMPENSATED ROW VECTORS IN THE DRIFT-COMPENSATED ARRAY

Fig. 11

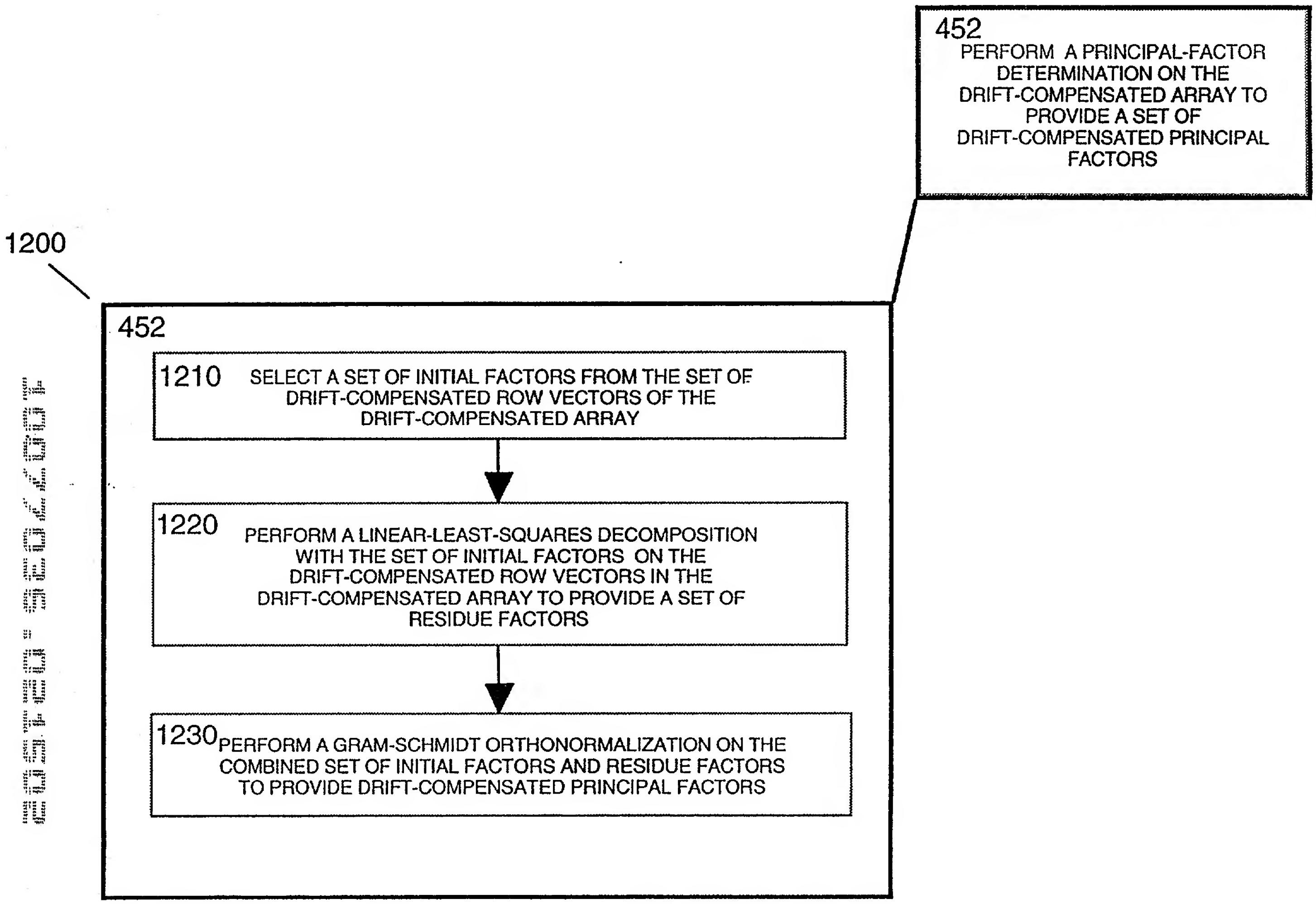
452
PERFORM A PRINCIPAL-FACTOR DETERMINATION ON THE DRIFT-COMPENSATED ARRAY TO PROVIDE A SET OF DRIFT-COMPENSATED PRINCIPAL FACTORS
1200
452
1210 SELECT A SET OF INITIAL FACTORS FROM THE SET OF DRIFT-COMPENSATED ROW VECTORS OF THE DRIFT-COMPENSATED ARRAY
1220 PERFORM A LINEAR-LEAST-SQUARES DECOMPOSITION WITH THE SET OF INITIAL FACTORS ON THE DRIFT-COMPENSATED ROW VECTORS IN THE DRIFT-COMPENSATED ARRAY TO PROVIDE A SET OF RESIDUE FACTORS
1230 PERFORM A GRAM-SCHMIDT ORTHONORMALIZATION ON THE COMBINED SET OF INITIAL FACTORS AND RESIDUE FACTORS TO PROVIDE DRIFT-COMPENSATED PRINCIPAL FACTORS

Fig. 12

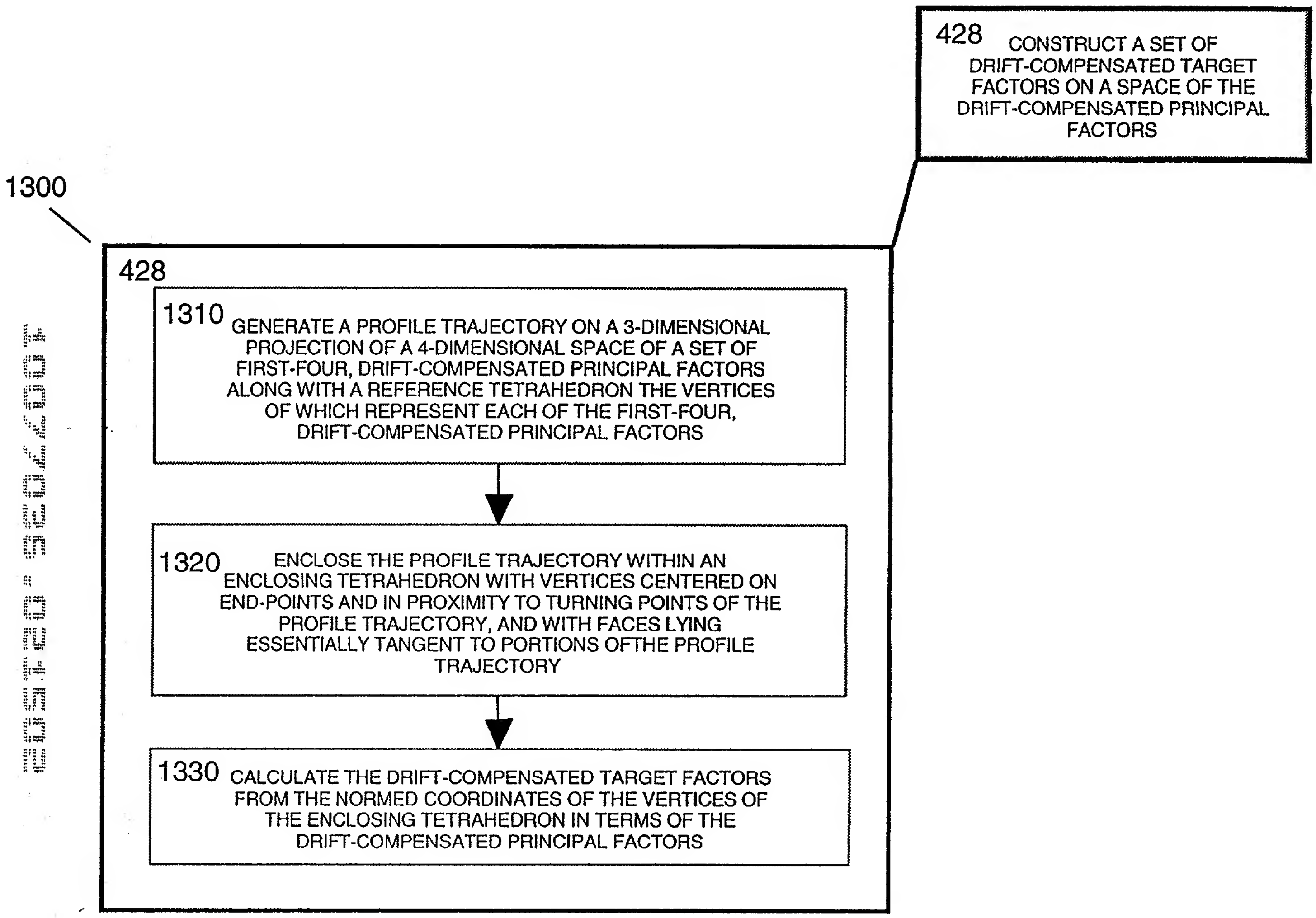
428 CONSTRUCT A SET OF DRIFT-COMPENSATED TARGET FACTORS ON A SPACE OF THE DRIFT-COMPENSATED PRINCIPAL FACTORS
1300
428
1310 GENERATE A PROFILE TRAJECTORY ON A 3-DIMENSIONAL PROJECTION OF A 4-DIMENSIONAL SPACE OF A SET OF FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS ALONG WITH A REFERENCE TETRAHEDRON THE VERTICES OF WHICH REPRESENT EACH OF THE FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS
1320 ENCLOSE THE PROFILE TRAJECTORY WITHIN AN ENCLOSING TETRAHEDRON WITH VERTICES CENTERED ON END-POINTS AND IN PROXIMITY TO TURNING POINTS OF THE PROFILE TRAJECTORY, AND WITH FACES LYING ESSENTIALLY TANGENT TO PORTIONS OFTHE PROFILE TRAJECTORY
1330 CALCULATE THE DRIFT-COMPENSATED TARGET FACTORS FROM THE NORMED COORDINATES OF THE VERTICES OF THE ENCLOSING TETRAHEDRON IN TERMS OF THE DRIFT-COMPENSATED PRINCIPAL FACTORS

Fig. 13

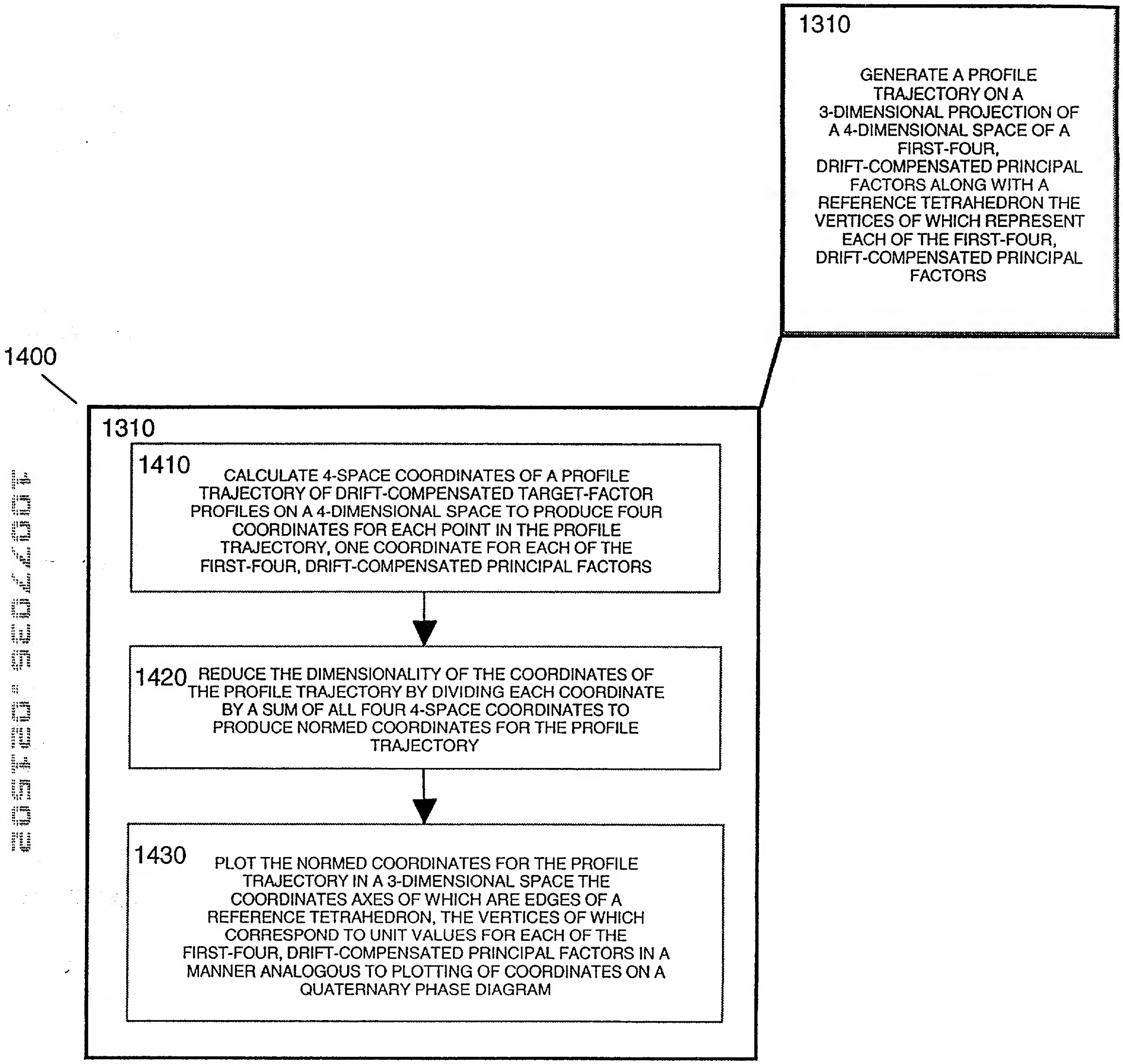
1310
GENERATE A PROFILE TRAJECTORY ON A 3-DIMENSIONAL PROJECTION OF A 4-DIMENSIONAL SPACE OF A FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS ALONG WITH A REFERENCE TETRAHEDRON THE VERTICES OF WHICH REPRESENT EACH OF THE FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS
1400
1310
1410 CALCULATE 4-SPACE COORDINATES OF A PROFILE TRAJECTORY OF DRIFT-COMPENSATED TARGET-FACTOR PROFILES ON A 4-DIMENSIONAL SPACE TO PRODUCE FOUR COORDINATES FOR EACH POINT IN THE PROFILE TRAJECTORY, ONE COORDINATE FOR EACH OF THE FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS
1420 REDUCE THE DIMENSIONALITY OF THE COORDINATES OF THE PROFILE TRAJECTORY BY DIVIDING EACH COORDINATE BY A SUM OF ALL FOUR 4-SPACE COORDINATES TO PRODUCE NORMED COORDINATES FOR THE PROFILE TRAJECTORY
1430 PLOT THE NORMED COORDINATES FOR THE PROFILE TRAJECTORY IN A 3-DIMENSIONAL SPACE THE COORDINATES AXES OF WHICH ARE EDGES OF A REFERENCE TETRAHEDRON, THE VERTICES OF WHICH CORRESPOND TO UNIT VALUES FOR EACH OF THE FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS IN A MANNER ANALOGOUS TO PLOTTING OF COORDINATES ON A QUATERNARY PHASE DIAGRAM

Fig. 14

1320 & 1330

ENCLOSE THE PROFILE TRAJECTORY WITHIN AN ENCLOSING TETRAHEDRON WITH VERTICES CENTERED ON END-POINTS AND IN PROXIMITY TO TURNING POINTS OF THE PROFILE TRAJECTORY, AND WITH FACES LYING ESSENTIALLY TANGENT TO PORTIONS OF THE PROFILE TRAJECTORY; AND, CALCULATE THE DRIFT-COMPENSATED TARGET FACTORS FROM THE NORMED COORDINATES OF THE VERTICES OF THE ENCLOSING TETRAHEDRON IN TERMS OF THE DRIFT-COMPENSATED PRINCIPAL FACTORS

1500

1320 & 1330

1510 PLACE VERTICES OF AN ENCLOSING TETRAHEDRON AT LOCI OF HEAVY POINT CONCENTRATIONS OF A PROFILE TRAJECTORY

↓

1520 ADJUST THE EDGES OF AN ENCLOSING TETRAHEDRON TO LIE ALONG ESSENTIALLY STRAIGHT LINE SEGMENTS

↓

1530 PLACE REMAINING VERTICES OF AN ENCLOSING TETRAHEDRON SO AS TO LIE NEAR THE TURNING POINTS OF THE PROFILE TRAJECTORY

↓

1540 ADJUST THE FACES OF THE ENCLOSING TETRAHEDRON TO LIE ALONG CURVED SEGMENTS JOINING A TURNING POINT AND ESSENTIALLY STRAIGHT LINE SEGMENTS OF THE PROFILE TRAJECTORY

Fig. 15

1600

1610 DISPLAY ON A COMPUTER MONITOR THE PROFILE TRAJECTORY OF THE PROJECTIONS OF A SEQUENCE OF ROW VECTORS AND THE REFERENCE TETRAHEDRON ESSENTIALLY SPANNING THE SPACE OF THE PROJECTIONS OF THE FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS

1620 GENERATE AN ENCLOSING TETRAHEDRON BY STARTING WITH A COPY OF THE REFERENCE TETRAHEDRON AND MOVING ITS VERTICES TO ENCLOSE THE PROFILE TRAJECTORY USING SOFTWARE BASED ON METHODS WELL KNOWN IN THE ART OF THE DISPLAY OF GRAPHICALLY GENERATED COMPUTER OBJECTS

1630 DRAG THE VERTICES OF THE ENCLOSING TETRAHEDRON TO THE LOCI OF HEAVY POINT CONCENTRATIONS IN THE PROFILE TRAJECTORY

1640 DRAG ANY REMAINING VERTICES OF THE ENCLOSING TETRAHEDRON TO POSITION THEM IN THE VICINITY OF ANY TURNING POINTS IN THE PROFILE TRAJECTORY SO THAT ESSENTIALLY STRAIGHT LINE SEGMENTS LIE IN CLOSE PROXIMITY TO EDGES OF THE ENCLOSING TETRAHEDRON ; AND, PLACE THE FACES OF THE ENCLOSING TETRAHEDRON ON OR IN CLOSE PROXIMITY TO ANY CURVED PORTIONS OF THE TRAJECTORY THAT CONNECT TURNING POINTS

1650 ,APPLY MINOR ADJUSTMENTS TO THE LOCATION OF THE VERTICES OF THE ENCLOSING TETRAHEDRON TO ENCLOSE THE SUBSPACE OF THE PROFILE TRAJECTORY WITH A MINIMAL VOLUME THAT BEST FITS THE DRIFT CORRECTED DATA REPRESENTED BY THE PROFILE TRAJECTORY, PROVIDING AN ENCLOSING TETRAHEDRON, THE VERTICES OF WHICH CORRESPOND WITH THE DRIFT-COMPENSATED TARGET FACTORS OF THE ANALYSIS

1660 DEFINE THE NORMED COORDINATES OF THE VERTICES OF THE ENCLOSING TETRAHEDRON RELATIVE TO THE REFERENCE TETRAHEDRON AS THE ENCLOSING-VERTEX WEIGHTING FACTORS USED TO OBTAIN THE DRIFT-COMPENSATED TARGET FACTORS FROM THE NORMALIZED FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTORS

1670 OBTAIN THE VECTORS GIVING THE DRIFT-COMPENSATED TARGET FACTORS FOR EACH VERTEX OF THE ENCLOSING TETRAHEDRON BY SUMMING THE PRODUCTS OF EACH ENCLOSING-VERTEX WEIGHTING FACTOR WITH THE VECTOR GIVING THE NORMALIZED FIRST-FOUR, DRIFT-COMPENSATED PRINCIPAL FACTOR THAT CORRESPONDS TO EACH VERTEX OF THE REFERENCE TETRAHEDRON

Fig. 16

1700

436

1710 OBTAIN THE SET OF DRIFT-COMPENSATED TARGET-FACTOR PROFILE VALUES BY APPLYING THE SET OF DRIFT-COMPENSATED TARGET FACTORS TO THE PROFILE TRAJECTORY BY ASCERTAINING THE NORMED COORDINATES OF EACH POINT ON THE PROFILE TRAJECTORY, I.E. THE TARGET-FACTOR WEIGHTING FACTORS, FROM THE ENCLOSING TETRAHEDRON IN A MANNER ANALOGOUS TO FINDING COORDINATES OF A POINT ON A QUATERNARY PHASE DIAGRAM

↓

1720 COMPOSE A REFERENCE VECTOR BY SUMMING THE PRODUCTS FROMED BY MULTIPLYING THE VECTORS CORRESPONDING TO THE DRIFT-COMPENSATED TARGET FACTORS BY THE TARGET-FACTOR WEIGHTING FACTORS, FOR EACH POINT ON THE PROFILE TRAJECTORY

↓

1730 SCALE THE AMPLITUDE OF THE RESULTING REFERENCE VECTOR TO OPTIMALLY MATCH THE CORRESPONDING ROW VECTOR COMPENSATED FOR THE EFFECTS OF DRIFT

↓

1740 DETERMINE A CORRESPONDING SCALING FACTOR AS THE SCALAR VALUE THAT OPTIMALLY MATCHES THE REFERENCE VECTOR TO THE ROW VECTOR

↓

1750 MULTIPLY THIS SCALING FACTOR BY THE NORMED COORDINATES OF THE PROFILE TRAJECTORY, I.E. THE TARGET-FACTOR WEIGHTING FACTORS, TO OBTAIN THE PRODUCT OF EACH INDIVIDUAL TARGET-FACTOR WEIGHTING FACTOR WITH THE SCALING FACTOR, I.E. SCALED TARGET-FACTOR WEIGHTING FACTORS

↓

1760 OUTPUT OR DISPLAY THE PROFILES AS A SET OF CURVES CORRESPONDING TO THE SCALED TARGET-FACTOR WEIGHTING FACTORS, I.E. DRIFT-COMPENSATED TARGET-FACTOR PROFILE VALUES, FOR EACH DRIFT-COMPENSATED TARGET FACTOR THAT CONTRIBUTES TO A PARTICULAR ROW VECTOR REPRESENTED BY A POINT ON THE PROFILE TRAJECTORY

436 OUTPUT ANALYTICAL RESULTS SELECTED FROM THE GROUP CONSISTING OF A SET OF DRIFT-COMPENSATED SCALED TARGET-FACTOR PROFILES DERIVED FROM THE SET OF TARGET-FACTOR WEIGHTING FACTORS, AND THE SET OF DRIFT-COMPENSATED TARGET FACTORS

Fig. 17

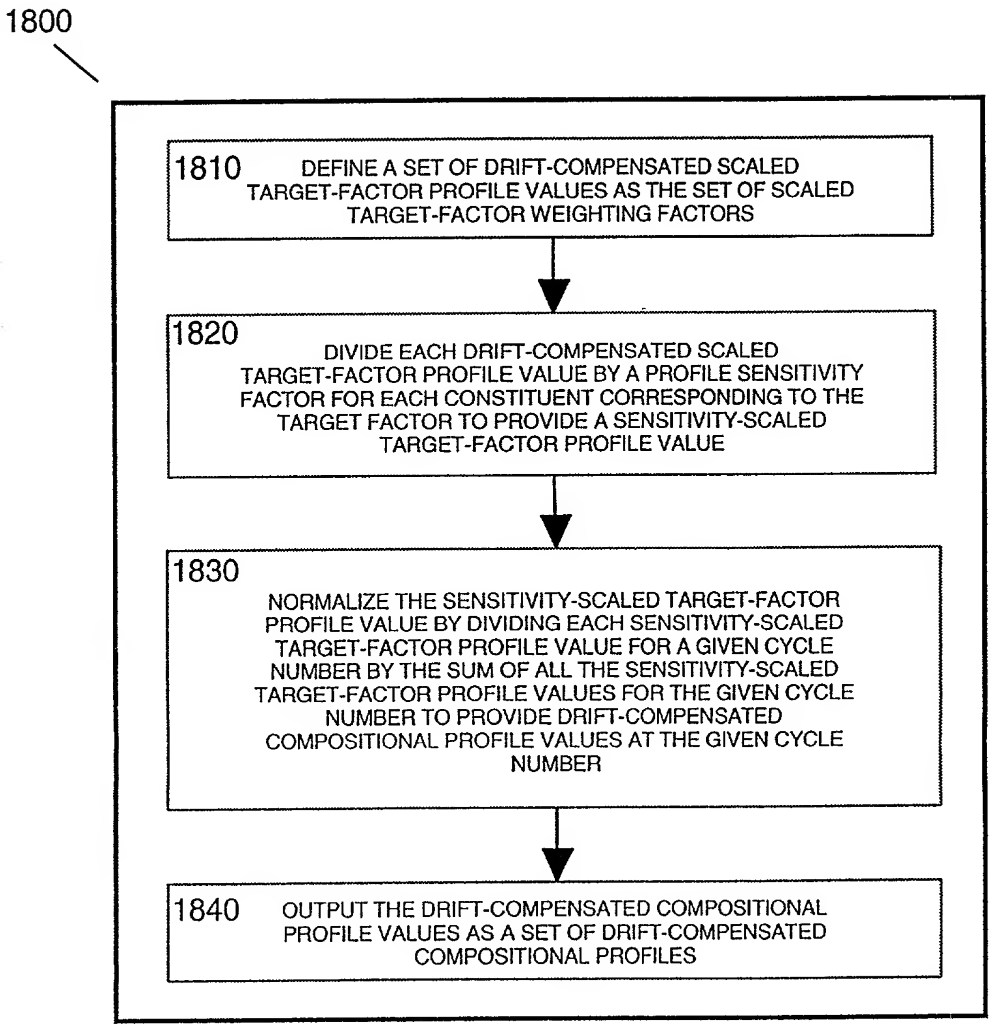
1800
1810 DEFINE A SET OF DRIFT-COMPENSATED SCALED TARGET-FACTOR PROFILE VALUES AS THE SET OF SCALED TARGET-FACTOR WEIGHTING FACTORS
1820 DIVIDE EACH DRIFT-COMPENSATED SCALED TARGET-FACTOR PROFILE VALUE BY A PROFILE SENSITIVITY FACTOR FOR EACH CONSTITUENT CORRESPONDING TO THE TARGET FACTOR TO PROVIDE A SENSITIVITY-SCALED TARGET-FACTOR PROFILE VALUE
1830 NORMALIZE THE SENSITIVITY-SCALED TARGET-FACTOR PROFILE VALUE BY DIVIDING EACH SENSITIVITY-SCALED TARGET-FACTOR PROFILE VALUE FOR A GIVEN CYCLE NUMBER BY THE SUM OF ALL THE SENSITIVITY-SCALED TARGET-FACTOR PROFILE VALUES FOR THE GIVEN CYCLE NUMBER TO PROVIDE DRIFT-COMPENSATED COMPOSITIONAL PROFILE VALUES AT THE GIVEN CYCLE NUMBER
1840 OUTPUT THE DRIFT-COMPENSATED COMPOSITIONAL PROFILE VALUES AS A SET OF DRIFT-COMPENSATED COMPOSITIONAL PROFILES

Fig. 18

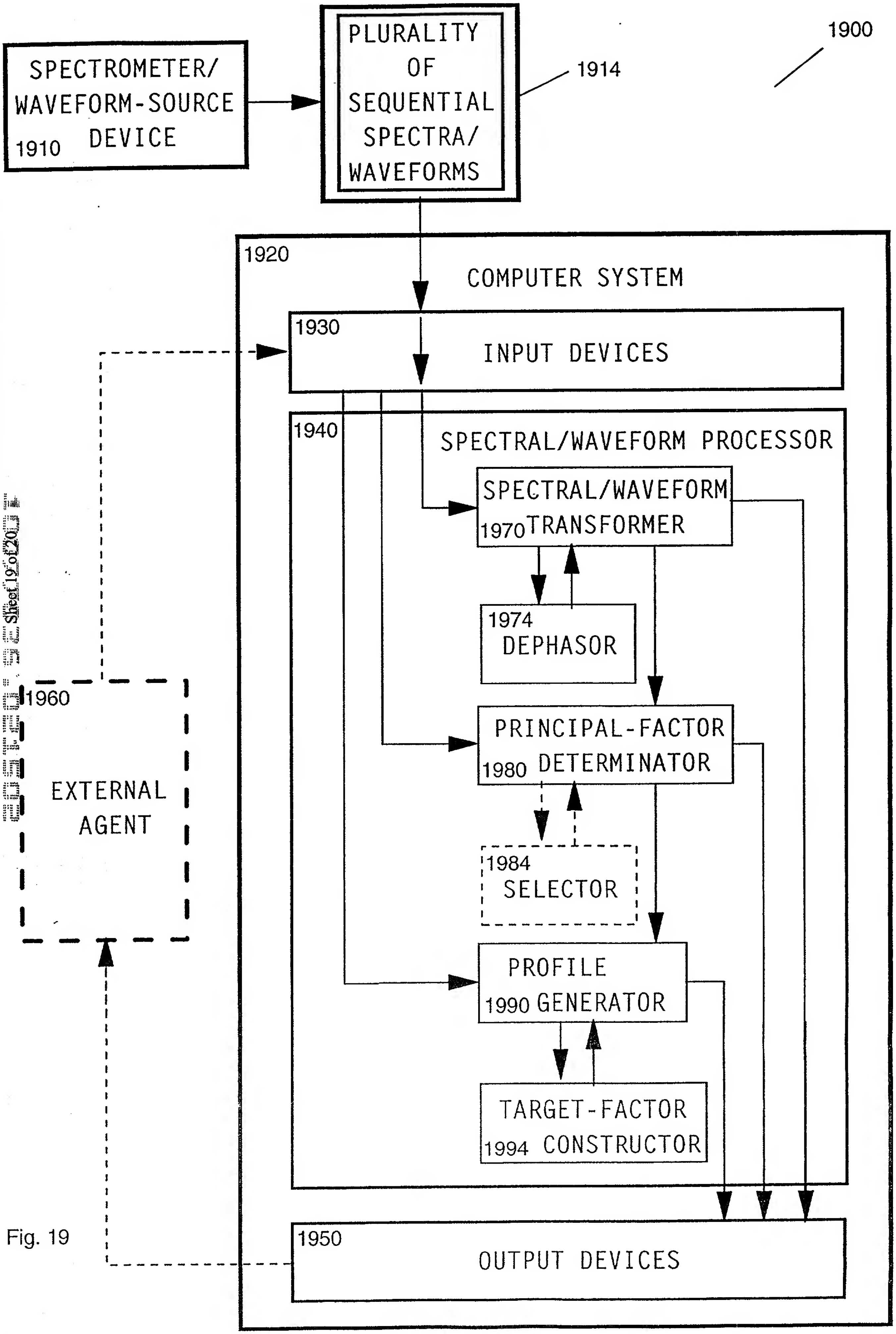
1900
SPECTROMETER/ WAVEFORM-SOURCE DEVICE
1910
PLURALITY OF SEQUENTIAL SPECTRA/ WAVEFORMS
1914
1920
COMPUTER SYSTEM
1930
INPUT DEVICES
1940
SPECTRAL/WAVEFORM PROCESSOR
SPECTRAL/WAVEFORM TRANSFORMER
1970
1974
DEPHASOR
PRINCIPAL-FACTOR DETERMINATOR
1980
1984
SELECTOR
PROFILE GENERATOR
1990
TARGET-FACTOR CONSTRUCTOR
1994
1950
OUTPUT DEVICES
1960
EXTERNAL AGENT

Fig. 19

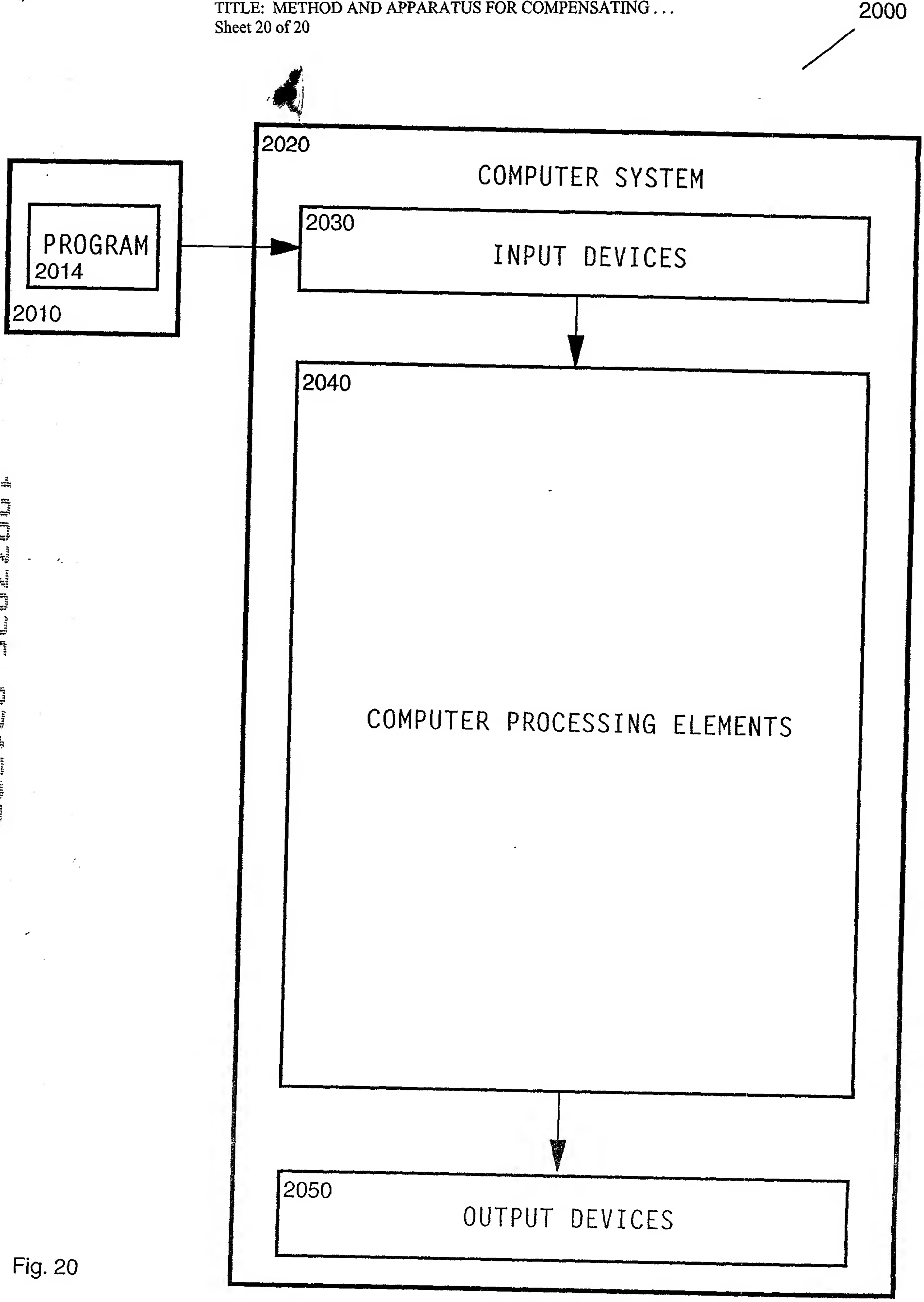
2000
2020
COMPUTER SYSTEM
PROGRAM
2014
2010
2030
INPUT DEVICES
2040
COMPUTER PROCESSING ELEMENTS
2050
OUTPUT DEVICES

Fig. 20